EVALUATION PROGRAM

for

SECONDARY SPACECRAFT CELLS

INITIAL EVALUATION TESTS

OF

GENERAL ELECTRIC COMPANY

STANDARD AND TEFLONATED NEGATIVE ELECTRODE

20.0 AMPERE-HOUR, NICKEL-CADMIUM SPACECRAFT CELLS

WITH AUXILIARY ELECTRODES

prepared for

GODDARD SPACE FLIGHT CENTER

CONTRACT S-23404-G

WEAPONS QUALITY ENGINEERING CENTER

NAVAL AMMUNITION DEPOT, CRANE, INDIANA

DEPARTMENT OF THE NAVY
NAVAL AMMUNITION DEPOT
WEAPONS QUALITY ENGINEERING CENTER
CRANE, INDIANA 47522

EVALUATION PROGRAM FOR SECONDARY SPACECRAFT CELLS

INITIAL EVALUATION TESTS OF GENERAL ELECTRIC COMPANY STANDARD AND TEFLONATED NEGATIVE ELECTRODE 20.0 AMPERE-HOUR, NICKEL-CADMIUM SPACECRAFT CELLS WITH AUXILIARY ELECTRODES

WQEC/C 74-337

1 JULY 1974

PREPARED BY

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Enclosure (1)

REPORT BRIEF

INITIAL EVALUATION TESTS OF STANDARD AND TEFLONATED NEGATIVE ELECTRODE 20.0 AMPERE-HOUR, NICKEL-CADMIUM SPACECRAFT CELLS WITH AUXILIARY ELECTRODES MANUFACTURED BY GENERAL ELECTRIC COMPANY

Ref: (a) NASA Purchase Order S-23404-G
(b) Initial Evaluation Test Procedure for Nickel-Cadmium Sealed Space Cells: NADC 3053-TP324, 10 Apr 1973

I. TEST ASSIGNMENT BRIEF

A. The purpose of this evaluation test program is to insure that all cells put into the life cycle program are of high quality by the screening of cells found to have electrolyte leakage, internal shorts, low capacity, or inability of any cell to recover its open-circuit voltage above 1.150 volts during the internal short test.

B. The 20 cells were manufactured for the National Aeronautics and Space Administration, Goddard Space Flight Center, under the NASA contract number NAS-5-17876, by General Electric Company, Gainesville, Florida. They were manufactured to Goddard Space Flight Center's specification number S-761-P-6, in which 10 cells have teflonated, negative electrodes (TFE-II). The electrodes of these cells were teflonated prior to the Electrochemical Cleaning Test (ECT) and were identified by General Electric catalog number 42B020AB29-G4. The other cells had catalog number 42B020AB30-G4 and had standard electrodes. These cells are rated at 20.0 ampere-hours, contain double ceramic seals, and were fitted with pressure gauge assemblies prior to testing. All cells contain a teflon-coated (one side only, next to cell case), sintered, nickel plaque auxiliary electrode, located along the narrow edge on the negative terminal side of the cell. The auxiliary resistor used throughout the test was 300 ohms. Testing was funded in accordance with reference (a).

C. Test limits specify those values in which a cell is to be terminated from a particular charge or discharge. Requirements are referred to as normally expected values based on past performance of aerospace nickel-cadmium cells with demonstrated life characteristics. A requirement does not constitute a limit for discontinuance from test.

II. SUMMARY OF RESULTS

A. The average weight of the teflonated negative plate cells was 28.7 grams heavier than the standard plate cells. This is attributed to the amount of electrolyte (greater for the teflonated cells) in the two cell designs.

B. The cell containers had a convex contour, in which the average thickness of the cells was 0.013 inch thicker at the maximum thickness when compared to the minimum thickness, which was the edge of the container. Following test, this value was 0.010 inch, indicating a reduction in the plate stack thickness, although some cells did increase in thickness.

C. The standard plate cells exhibited higher average end-of-charge (EOC) voltages than the cells with teflonated negative plates; they also delivered a higher capacity output in ampere-hours (ah) following these charges. The following is a listing of these averages:

	Teflonated Cells		Standard Plate Cells	
Charge	Volts	ah Out	Volts	ah Out
C/20 for 48 hours @ 25°C	1.435	29.9	1.436	30.9
C/10 for 24 hours @ 25°C	1.442	29.8	1.448	30.8
C/10 for 24 hours @ 20°C	1.451	28.5	1.454	29.8
C/10 for 24 hours @ 20°C	1.451	27.2	1.456	28.0
C/40 for 20 hours @ 20°C*	1.365	5.4	1.367	5.6
C/20 for 60 hours @ 0°C	1.472	28.6	1.477	29.1
C/10 for 24 hours @ 35°C	1.406	29.9	1.407	30.1

*Charge Efficiency Test, 10 ah input.

D. During the auxiliary electrode characteristic tests, maximum signal power was obtained with a 200-ohm resistance; but a 300-ohm resistance was used throughout the tests as instructed by the Goddard Space Flight Center Technical Officer.

E. The average cell voltage at the end of one week open-circuit, during the charge retention test, was 1.314 volts.

F. The 24-hour average cell voltage following a 16-hour short period, for the teflonated and standard negative plate cells was 1.203 and 1.210 volts respectively.

G. Seven teflonated negative plate cells delivered less than 55% of the input capacity requirement during the 20°C charge efficiency test.

H. All the cells reached a pressure of 20 psia before reaching the voltage limit of 1.550 volts during the pressure versus capacity test. The average ampere-hours in and voltages at this pressure were 33.6 and 1.505 volts respectively for the teflonated negative plate cells and 35.5 and 1.523 volts for the standard plate cells. All cells exhibited pressure decay in the range of 1 to 7 psia during the last 30 minutes of the 1-hour open-circuit stand. Average capacity out for the teflonated and standard negative plate cells was 29.4 and 29.9 ampere-hours respectively.

DEPARTMENT OF THE NAVY
NAVAL AMMUNITION DEPOT
CRANE, INDIANA 47522

IN REPLY REFER TO:
3053-JDH:wh
8900
21 AUG 1974

From: Commanding Officer, Naval Ammunition Depot, Crane, Indiana
To: National Aeronautics and Space Administration, Goddard Space Flight Center (711.2), Greenbelt, Maryland 20771

Subj: Report WQEC/C 74-337; Evaluation program for secondary spacecraft cells; initial evaluation tests of standard and teflonated negative electrode, 20.0 ampere-hour, nickel-cadmium spacecraft cells with auxiliary electrodes manufactured by General Electric Company

Ref: (a) NASA Purchase Order S-23404-G

Encl: (1) Report WQEC/C 74-337

1. In compliance with reference (a), enclosure (1) is forwarded for information and retention.

D. G. Miley

D. G. MILEY
By direction

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Distribution List

III. RECOMMENDATIONS

A. Manufacturing processes and controls should be such to prevent swelling of the plate stack, thereby preventing cell case distortion.

B. It is recommended that the cells be placed on life test to evaluate and compare the teflonated negative plate electrode cells with the standard plate cells.

RESULTS OF INITIAL EVALUATION TESTS OF GENERAL ELECTRIC COMPANY STANDARD AND TEFLONATED NEGATIVE ELECTRODE 20.0 AMPERE-HOUR NICKEL-CADMIUM SPACECRAFT CELLS WITH AUXILIARY ELECTRODES

I. TEST CONDITIONS AND PROCEDURE

A. All evaluation tests were performed at room ambient (RA) pressure and temperature (25° ± 2°C), with discharges at the 2-hour rate, and in accordance with reference (b), unless otherwise specified, and consisted of the following:

1. Phenolphthalein leak tests (2).

2. Three capacity tests, third at 20°C, with internal resistance measurements during second charge/discharge.

3. Auxiliary electrode characterization test.

4. Charge retention test, 20°C.

5. Internal short test.

6. Charge efficiency test, 20°C.

7. Overcharge tests, 0°C and 35°C.

8. Pressure versus capacity test.

9. Phenolphthalein leak test.

See Appendix I for summary of test procedure.

II. CELL IDENTIFICATION AND DESCRIPTION

A. Ten cells were manufactured with standard plates while the other 10 had a teflonated negative plate. The cells were identified by the manufacturer's catalog and serial numbers as follows:

Manufacturer's Number		
Catalog	Serial	Type Negative Plates
42B020AB29	1-10	Teflonated
42B020AB30	1-10	Standard

The cells were fitted with pressure gauge assemblies and placed in temporary pack configurations for initial testing (Packs 513X, 514X and 515X).

B. The 20.0 ampere-hour cell is rectangular with an average weight and physical dimensions as follows:

		Thickness (in.)			
Weight (g)*	Overall Height (in.)	Minimum	Pre-Test Maximum	Post-Test Maximum	Width (in.)
132.7**	6.908	0.896	0.909	0.906	3.007
1293.0					

*Manufacturer's data with swagelock fittings
**Teflonated negative plate

C. The cell containers and covers are made of stainless steel. The positive and negative terminals are insulated from the cell cover by ceramic seals and protrude through the cover as solder-type terminals.

D. The auxiliary electrode is a teflon-coated (one side only, next to cell case), sintered, nickel plaque located along the narrow edge of the negative terminal side of the cell, 0.3 centimeter below the top of the plate stack. The tab is welded between the cell cover and the case. Its physical area is approximately 10 square centimeters (1.9 cm x 5.1 cm) with a bag-type enclosure of pellon 2505K4 material. The auxiliary resistor is 300 ohms.

III. RESULTS--THE FOLLOWING WAS CONDENSED FROM TABLES I THROUGH VII

A. The average weight of the teflonated negative plate cells was 28.7 grams heavier than that of the standard plate cells. This is attributed to the amount of electrolyte (greater for teflonated cells) in the two cell designs.

B. The cell containers had a convex contour, in which the average thickness of the cells was 0.013 inch thicker at the maximum thickness when compared to the minimum thickness, which was the edge of the container. Following test, this value was 0.010 inch, indicating a reduction in the plate stack thickness, although some cells did increase in thickness.

C. The standard plate cells exhibited higher average end-of-charge (EOC) voltages than the cells with teflonated negative plates; they also delivered a higher capacity output in ampere-hours (ah) following these charges. The following is a listing of these averages:

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C/40 for 20 hours @ 20°C*	1.365	5.4	1.367	5.6
C/20 for 60 hours @ 0°C	1.472	28.6	1.477	29.1
C/10 for 24 hours @ 35°C	1.406	29.9	1.407	30.1

*Charge Efficiency Test, 10 ah input.

D. Average Internal Resistance Measurements (milliohms):

Measurement Taken	Resistance
30 min. before end-of-charge (Cycle 1)	2.20
1 hr. after start-of-discharge (Cycle 2)	2.18
2 hrs. after start-of-discharge (Cycle 2)	2.15

E. Maximum power was obtained with a 200-ohm resistor during the resistance characteristic test, although a 300-ohm resistor was used throughout the tests as instructed by the Goddard Space Flight Center Technical Officer.

F. The average cell voltage at the end of one week open-circuit, during the charge retention test, was 1.314 volts.

G. The 24-hour average cell voltage following a 16-hour short period, for the teflonated and standard negative plate cells was 1.203 and 1.210 volts respectively.

H. Seven teflonated negative plate cells delivered less than 55% of the input capacity requirement during the 20°C charge efficiency test.

I. All the cells reached a pressure of 20 psia before reaching the voltage limit of 1.550 volts during the pressure versus capacity test. The average ampere-hours in and voltages at this pressure were 33.6 and 1.505 volts respectively for the teflonated negative plate cells and 35.5 and 1.523 volts for the standard plate cells. All cells exhibited pressure decay in the range of 1 to 7 psia during the last 30 minutes of the 1-hour open-circuit stand. Average capacity out for the teflonated and standard negative plate cells was 29.4 and 29.9 ampere-hours respectively.

APPENDIX I

GENERAL ELECTRIC COMPANY
20.0 AMPERE-HOUR CELLS

APPENDIX I

I. TEST PROCEDURE

A. Phenolphthalein Leak Tests:

1. This test is a determination of the condition of the welds and ceramic seals on receipt of the cells and following the last discharge of the cells (Cycle #8).

2. The cells were initially checked with a one-half of one percent phenolphthalein solution applied with a cotton swab and then placed in a vacuum chamber and exposed to a vacuum of 40 microns of mercury or less for 24 hours. Upon removal they were rechecked for leaks and then received a final check following test completion. The requirement is no red or pink discoloration which indicates a leak.

B. Capacity Tests:

1. The capacity test is a determination of the cells' capacity at the C/2 discharge rate to 0.75 volt per cell, where C is the manufacturer's rated capacity. This type discharge follows all charges of this evaluation test.

2. The charges for the capacity tests are as follows:

a. C/20, 48 hours, room ambient (RA), Cycle 0, with a test limit of 1.52 volts or pressure of 100 psia.

b. C/10, 24 hours, RA, Cycle 1, with a test limit of 1.52 volts or 100 psia pressure and a requirement of maximum voltage (1.48) or pressure (65 psia).

c. C/10, 24 hours, 20°C, Cycle 2, with the same limits and requirements as the charge of Cycle 1.

C. Special Resistance Characterization Tests for Auxiliary Electrode Cells:

1. The purpose of this test is to determine the resistance to be placed across the cell's auxiliary electrode and negative terminals which will provide maximum signal when the cell is fully charged.

2. The cells are charged at C/10 for 24 hours at the room ambient temperature following their initial charge/discharge cycle. Following this the cells are continued on charge with the current reduced, if necessary, to maintain the cell's voltage below 1.520

volts and to stabilize the pressure between 10-20 psia. Resistance values, between 10,000 ohms and 0.1 ohm are then placed between the auxiliary electrode and the negative terminal. The cells are allowed a minimum of 5 minutes, at each resistance value, to obtain an equilibrium voltage across this resistance. This voltage value is then recorded and by calculation using the equation $P = E^2/R$ the resistance that produces maximum power is determined.

D. Internal Resistance:

1. Measurements are taken across the cell terminals 1/2 hour before the end-of-charge (EOC) on Cycle 1 and 1 and 2 hours after the start-of-discharge of Cycle 2. These measurements were made with a Hewlett-Packard milliohmmeter (Model 4328A).

E. Special Charge Retention Test, 20°C:

1. This test is to establish the capacity retention of each cell following a 7-day open-circuit-stand in a charge mode.

2. The cells are charged at C/10 for 24 hours with a test limit of 1.52 volts or 100 psia pressure. They then stand on open-circuit for 7 days, with the requirement that the open-circuit voltage of each cell, following this period, is within ± 5 millivolts of the average cell voltage. The cells are then discharged and 80 percent capacity out of that obtained in Cycle 3 is required.

F. Internal Short Test:

1. This test is a means of detecting slight shorting conditions which may exist because of imperfections in the insulating materials, or damage to element in handling or assembly.

2. Following completion of the third capacity discharge, the cells are shunted with a 0.5-ohm, 3-watt resistor for 16 hours. At the end of 16 hours the resistors are removed and the cells stand on open-circuit-voltage (OCV) for 24 hours. A minimum voltage of 1.15 is required at the end of 24 hours.

G. Charge Efficiency Test, 20°C:

1. This test is a measurement of the cells' charge efficiency when charged at a low current rate.

2. The cells are charged at C/40 for 20 hours with a test limit of 1.52 volts or 100 psia pressure. They are then discharged and the requirement is that the minimum capacity out equals 55 percent of capacity in during the preceding charge.

H. Overcharge Test #1, 0°C:

1. The purpose of this test is to determine the degree to which the cells will maintain a balanced voltage, and to determine the cells' capability to be overcharged without overcharging the negative electrode.

2. The cells are charged at C/20 for 60 hours. The test limits are cell voltages of 1.56 or greater for a continuous time period of 2 hours or pressures of 100 psia. The requirement is a voltage of 1.520 or a pressure of 65 psia. The cells are then discharged and 85 percent capacity out of that obtained in Cycle 3 is required.

I. Overcharge Test #2, 35°C:

1. This test is a measurement of the cells' capacity at a higher temperature when compared to its capacity at 20°C. This test also determines the cells' capability of reaching a point of pressure equilibrium; oxygen recombination at the negative plate at the same rate it is being generated at the positive plate.

2. The cells are charged at C/10 for 24 hours with a test limit of 1.52 volts or 100 psia pressure and a requirement of 1.45 volts or 65 psia pressure. The cells are then discharged with a requirement that capacity out equals 55 percent capacity out as obtained in Cycle 3.

J. Pressure versus Capacity Test:

1. The purpose of this test is to determine the capacity to a pressure and the pressure decay during charge and open circuit stand respectively.

2. Each cell is charged at C/2 to either a pressure of 20 psia or a voltage of 1.550. Recordings are taken on each cell when it reaches 5, 10, 15 and 20 psia pressure. The cells then stand OCV for 1 hour with 30-minute recordings and then are discharged, shorted out and leak tested.

TABLE I
MEASUREMENT AND LEAK TEST DATA

SERIAL NUMBER	WEIGHT* (Grams)	HEIGHT (Inches)	THICKNESS (Inches)			WIDTH (Inches)	PHENOLPHTHALEIN LEAK TESTS								
							INITIAL			POST HI VAC			POST TEST		
			MINIMUM	MAXIMUM (Pre-Test)	MAXIMUM (Post-Test)		Terminals +	Terminals -	Other	Terminals +	Terminals -	Other	Terminals +	Terminals -	Other
001	1342.0	6.915	.897	.905	.906	3.002									
002	1317.5	6.902	.898	.908	.908	3.012				-					
003	1325.2	6.913	.901	.910	.906	3.016									
004	1337.5	6.901	.895	.905	.905	3.020									
005	1318.3	6.907	.893	.904	.905	3.001									
006	1273.0	6.908	.898	.908	.911	3.007									
007	1337.5	6.904	.896	.908	.916	3.000									
008	1311.0	6.911	.896	.927	.910	3.030									
009	1318.0	6.915	.892	.910	.906	3.005									
010	1337.5	6.911	.892	.902	.900	3.004									
							No Leaks			No Leaks			No Leaks		
001	1316.2	6.916	.900	.907	.904	3.002									
002	1318.3	6.912	.896	.925	.904	3.012									
003	1307.0	6.892	.903	.911	.908	3.012									
004	1274.0	6.919	.893	.908	.903	3.007									
005	1301.5	6.901	.895	.904	.903	3.002									
006	1303.5	6.912	.892	.905	.902	3.003									
007	1254.5	6.910	.895	.911	.905	3.002									
008	1292.7	6.896	.894	.912	.905	3.000									
009	1308.3	6.911	.892	.911	.903	3.004									
010	1254.0	6.903	.894	.905	.907	3.009									
*	As per manufacturer's data, includes swage lock fittings.														

8 — AB29 — AB30

TABLE II
CAPACITY DATA

SERIAL NUMBER	CAPACITY TEST #1						CAPACITY TEST #2						CAPACITY TEST #3 (20°C)					
	END-OF-CHARGE			END-OF-DISCHARGE			END-OF-CHARGE			END-OF-DISCHARGE			END-OF-CHARGE			END-OF-DISCHARGE		
	CELL (Volts)	AUX ELECT (Volts)	PRESS (PSIA)	CAPAC-ITY (ah)	AUX ELECT (Volts)	PRESS (PSIA)	CELL (Volts)	AUX ELECT (Volts)	PRESS (PSIA)	CAPAC-ITY (ah)	AUX ELECT (Volts)	PRESS (PSIA)	CELL (Volts)	AUX ELECT (Volts)	PRESS (PSIA)	CAPAC-ITY (ah)	AUX ELECT (Volts)	PRESS (PSIA)
001	1.434	.533	32	29.6	-.003	2	1.444	.541	57	29.9	-.062	4	1.451	.544	63	28.4	.027	5
002	1.436	.418	25	30.3	-.026	3	1.433	.436	50	30.3	.070	4	1.453	.435	57	28.8	-.019	5
003	1.434	.406	22	29.6	-.039	6	1.441	.457	35	29.6	.066	5	1.452	.447	47	28.4	.040	8
004	1.435	.436	25	29.7	-.028	4	1.441	.486	45	29.7	.062	5	1.452	.491	52	28.1	.102	4
005	1.435	.518	25	29.5	-.016	5	1.441	.576	46	29.5	.102	5	1.453	.550	52	28.0	.049	6
006	1.436	.519	22	30.0	-.091	4	1.442	.549	45	29.7	.105	5	1.454	.548	52	28.1	.099	4
007	1.436	.493	25	29.6	.000	6	1.444	.542	48	29.7	.061	6	1.455	.538	56	28.2	.010	5
008	1.438	.427	24	30.3	-.045	2	1.446	.538	32	30.0	.067	5	1.446	.562	38	29.3	.006	2
009	1.438	.458	23	29.7	-.007	3	1.443	.553	49	29.6	-.272	5	1.445	.538	57	28.6	.064	2
010	1.433	.411	20	30.5	-.007	3	1.445	.472	41	30.5	.091	5	1.446	.467	47	29.1	.072	6
001	1.437	.377	11	30.7	-.086	3	1.451	.444	18	30.5	-.082	2	1.453	.461	25	29.5	.000	4
002	1.435	.430	13	30.6	-.114	3	1.448	.513	21	30.5	-.033	4	1.452	.541	31	29.5	-.014	4
003	1.434	.377	15	31.1	-.092	5	1.446	.405	19	31.1	-.071	5	1.453	.406	25	30.0	-.072	2
004	1.434	.391	12	31.1	-.202	2	1.446	.471	20	31.1	-.046	3	1.455	.494	30	30.0	-.041	2
005	1.435	.388	15	31.1	-.032	6	1.447	.451	21	30.9	-.024	5	1.455	.488	30	29.8	-.022	5
006	1.435	.414	23	30.6	-.106	2	1.448	.506	19	30.5	-.008	2	1.457	.530	29	29.2	.017	3
007	1.435	.378	25	31.1	-.157	3	1.449	.406	18	31.2	-.091	2	1.457	.400	22	30.2	-.062	2
008	1.438	.427	6	30.9	-.160	2	1.452	.550	18	30.8	-.040	2	1.453	.571	28	29.8	.015	2
009	1.440	.375	13	31.1	-.094	10	1.448	.448	33	30.9	-.032	11	1.451	.443	38	30.2	-.029	11
010	1.441	.398	10	30.5	-.032	2	1.450	.509	23	30.4	-.005	3	1.453	.516	29	29.8	.036	3

AB 29 — 6 — AB 30

9ND-NADC (SP 11/73)

TABLE III
INTERNAL RESISTANCE AND SHORT TEST DATA

9ND-NADC (SP 11/73)

SERIAL NUMBER	INTERNAL RESISTANCE (MILLIOHMS)			INTERNAL SHORT TEST		
	END-OF-CHARGE	ONE HOUR AFTER START-OF-DISCHARGE	TWO HOURS AFTER START-OF-DISCHARGE	AFTER 16 HR SHORT	AFTER 24 HOUR OCV STAND	
				CELL	CELL	PRESS
AB 29						
001	2.2	2.3	2.2	.009	1.201	4
002	2.3	2.3	2.1	.009	1.209	4
003	2.2	2.2	2.1	.009	1.201	5
004	2.2	2.3	2.2	.009	1.200	4
005	2.3	2.3	2.2	.008	1.205	4
006	2.3	2.3	2.2	.010	1.203	4
007	2.2	2.4	2.2	.008	1.205	5
008	2.1	2.0	2.0	.010	1.202	4
009	2.3	2.1	2.1	.009	1.199	3
010	2.2	2.1	2.1	.010	1.204	4
AB 30						
001	2.1	2.1	2.1	.042	1.211	4
002	2.2	2.2	2.2	.049	1.211	5
003	2.2	2.1	2.2	.011	1.209	2
004	2.2	2.1	2.1	.013	1.211	2
005	2.3	2.2	2.2	.052	1.212	5
006	2.1	2.1	2.1	.046	1.212	2
007	2.1	2.1	2.1	.015	1.210	1
008	2.1	2.1	2.1	.051	1.216	1
009	2.2	2.2	2.2	.047	1.207	9
010	2.2	2.1	2.2	.051	1.207	1

TABLE IV
Charge Efficiency and Overcharge Data

SERIAL NUMBER	Charge Efficiency (20°C) END-OF-CHARGE CELL (Volts)	AUX ELECT (Volts)	PRESS (PSIA)	END-OF-DISCHARGE CAPACITY (ah)	AUX ELECT (Volts)	PRESS (PSIA)	Overcharge Test (0°) END-OF-CHARGE CELL (Volts)	AUX ELECT (Volts)	PRESS (PSIA)	END-OF-DISCHARGE CAPACITY (ah)	AUX ELECT (Volts)	PRESS (PSIA)	Overcharge Test (35°C) END-OF-CHARGE CELL (Volts)	AUX ELECT (Volts)	PRESS (PSIA)	END-OF-DISCHARGE CAPACITY (ah)	AUX ELECT (Volts)	PRESS (PSIA)
AB 29 001	1.363	.022	4	5.1	.016	4	1.469	.484	58	28.6	.026	9	1.409	.493	30	30.0	.103	5
002	1.364	.021	4	5.2*	.011	4	1.472	.396	49	29.0	.063	6	1.406	.415	25	30.2	.086	5
003	1.365	.016	4	5.4	.012	4	1.472	.413	48	28.1	.113	10	1.408	.386	21	29.9	.035	9
004	1.364	.018	4	5.3	.035	4	1.474	.450	48	28.1	.045	8	1.406	.414	30	29.9	.078	5
005	1.363	.024	5	5.3	.035	4	1.474	.509	50	28.1	.113	9	1.405	.484	22	29.5	.125	9
006	1.364	.027	5	5.4	.023	4	1.474	.521	51	28.5	.094	6	1.408	.524	22	29.9	.100	5
007	1.364	.020	5	5.2*	.006	5	1.474	.478	50	28.4	.034	5	1.411	.453	23	30.0	.129	10
008	1.367	.059	5	5.6	.044	5	1.473	.443	42	29.3	.002	6	1.402	.434	15	29.5	-.003	5
009	1.367	.039	5	5.8	.029	5	1.470	.508	65	28.8	.046	10	1.403	.438	21	29.7	-.054	5
010	1.367	.028	5	5.8	.037	5	1.468	.442	50	29.6	.010	6	1.403	.417	20	30.2	.040	6
AB 30 001	1.367	.052	4	5.6	.027	4	1.476	.351	28	29.2	.006	6	1.405	.439	17	29.6	.017	6
002	1.367	.047	5	5.8	.054	4	1.475	.428	34	29.2	.132	9	1.407	.510	21	30.0	.065	6
003	1.366	.040	2	5.6	.046	3	1.475	.364	27	29.6	.037	4	1.408	.418	15	30.4	.014	5
004	1.367	.042	1	5.6	.028	1	1.475	.375	32	29.4	.048	5	1.408	.467	21	30.3	.032	4
005	1.367	.043	5	5.6	.051	5	1.478	.400	37	29.3	.073	10	1.407	.476	20	30.2	.052	10
006	1.367	.039	4	5.6	.029	3	1.479	.389	33	28.8	.082	7	1.410	.483	18	30.0	.050	5
007	1.367	.042	1	5.5	.024	1	1.479	.352	26	29.2	.012	6	1.410	.423	15	30.4	.023	5
008	1.368	.063	4	5.8	.042	4	1.479	.467	33	29.0	.168	6	1.406	.545	17	30.1	.077	4
009	1.367	.047	9	5.6	.036	9	1.480	.319	39	29.2	.028	11	1.407	.420	23	30.2	.046	11
010	1.367	.055	5	5.8	.047	5	1.479	.381	35	28.5	.127	8	1.408	.515	18	29.9	.036	4
*	Cells	Reversed	on	discharge	(-.095	and	-.138	volts).										

END-NADC (SP 11/73)

TABLE V (Teflon Cells)
PRESSURE VS. CAPACITY TEST DATA

Serial No.	001	002	003	004	005	006	007	008	009	010						
Start-of-Charge, Press.	4	4	6	4	6	4	5	5	5	6						
AH in to 5 PSIA	12.6	8.2		7.4		7.4										
Cell (volts)	1.415	1.440		1.407		1.408										
Aux (volts)	.098	.024		.015		.017										
AH in to 10 PSIA	29.2	30.4	28.5	28.5	28.5	29.2	28.5	31.8	30.0	28.6						
Cell (volts)	1.452	1.456	1.451	1.448	1.449	1.452	1.446	1.466	1.456	1.446						
Aux (volts)	.368	.342	.288	.291	.329	.363	.300	.369	.354	.301						
AH in to 15 PSIA	32.0	32.3	32.3	31.3	31.6	32.1	31.6	34.6	33.6	33.6						
Cell (volts)	1.490	1.484	1.502	1.479	1.484	1.491	1.478	1.506	1.499	1.485						
Aux (volts)	.446	.396	.408	.368	.417	.445	.388	.438	.432	.387						
AH in to 20 PSIA	32.5	33.5	32.8	32.5	33.1	33.1	33.1	35.7	34.2	35.3						
Cell (volts)	1.499	1.503	1.506	1.501	1.504	1.503	1.501	1.514	1.508	1.510						
Aux (volts)	.466	.385	.402	.381	.416	.474	.359	.456	.428	.360						
AH in to V/L (1.55V)																
Aux (volts)																
Press (PSIA)																
30 Min OCV, Cell	1.402	1.405	1.403	1.401	1.406	1.404	1.403	1.410	1.405	1.407						
Aux (volts)	.460	.388	.389	.400	.481	.482	.416	.445	.436	.393						
Press (PSIA)	22	22	22	20	23	22	23	19	23	20						
1 hour OCV, Cell	1.392	1.394	1.393	1.391	1.394	1.393	1.393	1.398	1.397	1.396						
Aux (volts)	.440	.363	.353	.365	.455	.449	.398	.410	.426	.370						
Press (PSIA)	20	19	18	18	17	18	17	15	22	18						
EOD AH out	29.1	29.6	29.1	29.2	29.1	29.3	29.3	29.9	29.2	30.1						
Aux (volts)	.185	.166	.104	.137	.182	.172	.138	.094	.089	.145						
Press (PSIA)	5	5	8	6	8	6	8	5	6	6						

TABLE V (Standard Cells)
PRESSURE VS. CAPACITY TEST DATA

Serial No.	001	002	003	004	005	006	007	008	009	010						
Start-of-Charge, Press.	5	5	5	4	6	5	5	4	10	4						
AH in to 5 PSIA				6.1				12.6		8.6						
Cell (volts)				1.404				1.417		1.409						
Aux (volts)				.009				.057		.020						
AH in to 10 PSIA	34.0	31.2	34.0	34.5	32.5	34.0	32.5	34.6		33.6						
Cell (volts)	1.501	1.460	1.488	1.502	1.468	1.489	1.467	1.513		1.503						
Aux (volts)	.365	.301	.396	.424	.309	.358	.358	.441		.398						
AH in to 15 PSIA	34.9	34.5	34.9	34.9	34.9	34.5	34.9	35.3	25.6	34.2						
Cell (volts)	1.521	1.517	1.510	1.511	1.509	1.516	1.512	1.523	1.437	1.518						
Aux (volts)	.442	.433	.438	.440	.406	.443	.443	.477	.128	.435						
AH in to 20 PSIA	35.4	35.2	35.8	36.0	35.8	35.2	36.0	35.7	35.0	35.0						
Cell (volts)	1.525	1.524	1.522	1.521	1.522	1.523	1.522	1.526	1.520	1.526						
Aux (volts)	.477	.471	.476	.477	.453	.486	.480	.510	.402	.479						
AH in to V/L (1.55V)																
Aux (volts)																
Press (PSIA)																
30 Min OCV, Cell	1.403	1.402	1.403	1.404	1.403	1.402	1.403	1.410	1.405	1.405						
Aux (volts)	.326	.378	.352	.341	.342	.353	.358	.449	.303	.378						
Press (PSIA)	15	18	15	20	18	15	17	16	18	17						
1 hour OCV, Cell	1.396	1.396	1.396	1.396	1.396	1.395	1.396	1.399	1.396	1.396						
Aux (volts)	.283	.341	.325	.313	.314	.317	.334	.396	.262	.328						
Press (PSIA)	12	15	11	13	15	13	14	14	16	13						
EOD AH out	29.7	29.8	30.2	29.8	30.2	29.7	30.2	30.0	29.9	29.6						
Aux (volts)	-.060	.079	.008	.072	.023	.081	.010	.073	.038	.025						
Press (PSIA)	6	7	5	5	6	6	6	5	11	4						

TABLE VI

SPECIAL RESISTANCE CHARACTERISTIC DATA ON THE AUXILIARY ELECTRODES

GND-NADC (SP 11/73)

SERIAL NO.	008 (AB29)		009 (AB29)				009 (AB30)		010 (AB30)		AVERAGE *	
OHMS	VOLTS	PRESS	VOLTS	PRESS	VOLTS	PRESS	VOLTS	PRESS	VOLTS	PRESS	VOLTS	MILLIWATTS
10,000	.821	15	.817	21			.836	20	.825	11	.819/.830	.067/.069
5,000	.794	15	.788	21			.729	20	.758	11	.791/.743	.125/.110
2,000	.704	15	.704	21			.642	20	.720	11	.704/.681	.248/.232
1,000	.605	15	.612	21			.527	20	.597	11	.608/.562	.370/.316
500	.489	15	.493	21			.381	20	.452	10	.491/.416	.482/.346
200	.331	14	.320	21			.265	20	.290	10	.325/.277	.528/.384
100	.231	14	.214	21			.153	20	.174	10	.222/.163	.493/.266
50	.153	14	.140	21			.105	19	.114	10	.146/.109	.426/.238
20	.084	14	.078	21			.056	19	.064	10	.081/.060	.328/.180
10	.050	14	.045	21			.030	19	.034	10	.047/.032	.221/.102
5	.028	14	.024	21			.016	19	.017	10	.026/.016	.135/.051
2	.012	14	.011	21			.007	19	.007	10	.011/.007	.061/.025
1	.007	14	.006	21			.004	19	.004	10	.006/.004	.036/.016
0.5	.004	14	.004	20			.002	19	.002	10	.004/.002	.032/.008
0.2	.002	14	.002	20			.002	19	.002	10	.002/.002	.020/.020
0.1	.002	14	.002	20			.001	19	.001	10	.002/.001	.040/.010

Note: All pressures in PSIA.

* AB29/AB30

$$\text{POWER} = \frac{V^2}{R} \text{ Watts } 10^3 \frac{\text{Milliwatts}}{\text{Watt}} : \text{Milliwatts}$$

TABLE VII
CHARGE RETENTION TEST DATA

AB 29

SERIAL NUMBER	END-OF-CHARGE			24 HR. OCV			1 WEEK OCV			END-OF-DISCHARGE		
	CELL (VOLTS)	AUX. ELECT. (VOLTS)	PRESS. (PSIA)	CELL (VOLTS)	AUX. ELECT. (VOLTS)	PRESS. (PSIA)	CELL (VOLTS)	AUX. ELECT (VOLTS	PRESS. (PSIA)	CAPAC-ITY (AH)	AUX. ELECT. (VOLTS)	PRESS. (PSIA)
001	1.451	.555	68	1.363	.146	5	1.314	.004	4	27.0	-.390	4
002	1.452	.442	62	1.363	.121	5	1.314	.003	4	27.3	-.089	2
003	1.451	.466	47	1.364	.096	9	1.315	.004	8	27.0	-.273	8
004	1.451	.523	57	1.363	.137	6	1.315	.004	5	27.1*	-.354	4
005	1.452	.555	57	1.363	.138	7	1.313	.004	6	26.6	-.205	6
006	1.453	.560	56	1.364	.123	5	1.315	.004	5	27.1*	-.273	3
007	1.453	.540	55	1.364	.106	6	1.316	.004	6	27.1*	-.305	5
008	1.451	.572	42	1.360	.121	5	1.313	.008	4	27.7	-.038	4
009	1.449	.551	65	1.362	.124	5	1.313	.005	4	27.5*	-.339	4
010	1.447	.485	55	1.362	.105	5	1.313	.004	4	28.1	-.188	4
001	1.455	.483	31	1.363	.093	5	1.312	.009	3	27.8	-.273	3
002	1.454	.552	38	1.364	.121	5	1.314	.008	5	27.8	-.175	4
003	1.455	.412	33	1.364	.099	4	1.314	.007	4	28.2	-.159	4
004	1.456	.495	33	1.364	.098	3	1.315	.006	2	28.1	-.082	1
005	1.457	.502	40	1.364	.111	6	1.314	.007	5	28.1	-.068	4
006	1.458	.536	35	1.364	.118	4	1.314	.007	4	27.7	-.213	2
007	1.459	.402	28	1.364	.092	2	1.314	.006	2	28.1	-.049	1
008	1.457	.582	37	1.363	.129	2	1.312	.007	1	28.1	-.184	1
009	1.456	.443	45	1.363	.078	11	1.316	.013	9	28.2	-.105	9
010	1.457	.537	38	1.363	.112	3	1.317	.015	2	27.7	-.043	2
*	Cells	Reversed	on	discharge	(-	.135,	-.156,	+.171	volts)	-.115		

AB 30

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Marathon Battery Company (Mr. Lou Belove), P. O. Box 8233, Waco, Texas 76710

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Martin-Marietta Corporation (M. S. 0455, Mr. Charles Bolton), P. O. Box 179, Denver, Colorado 80201

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TRW, Inc. (Librarian, TIM 3417), 23555 Euclid Avenue, Cleveland, Ohio 44117

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Union Carbide Corporation, Consumer Products Division, (Dr. Ralph Brodd), P. O. Box 6116, Cleveland, Ohio 44101

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United Aircraft Corporation (Library), 400 Main Street, East Hartford, Connnecticut 06108

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